

DRDC Acoustic Survey of Country Harbour Pipeline

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Defence R & D Canada – Atlantic

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Abstract

Defence Research and Development Atlantic was contracted to perform an acoustic survey of the Sable gas pipeline which comes ashore at Country Harbour, Nova Scotia. The experiment involved deploying a hydrophone to perform noise measurements in locations both close to and remote from the pipeline to determine if the pipeline produces significant above-ambient noise. Sound levels were recorded at various frequency ranges from 0-200 Hz to 0-12800 Hz with efforts focussing on the lower frequencies where pipeline noise might be expected. Baseline measurements taken at locations both away from and near to the pipeline showed mixed results. There was no clear trend with respect to sound level for the highest frequency bands, however, there did appear to be a significant increase in the 0-400 Hz range along with the appearance of some tonal lines. Further examination of points both along the pipeline and perpendicular to the pipeline showed little correlation between sound levels and distance from the pipeline. Analysis of the lower frequency ranges did show the presence of several tones which were not readily visible at the control sites. These tones occurred at 34 Hz, 41 Hz, 50 Hz, 67 Hz, 84 Hz, and 100 Hz. It is theorized that these tones were a result of flow in the pipeline. For most of the measurements, there was a fairly significant variation of sound level within a single measurement thus, while at some points the identified tones were clearly visible above the background noise, at others it was difficult to distinguish them from the noise without prior knowledge. Thus, while it appears likely that the flow in the pipeline is producing detectable noise, it is not clear that the level is significant, unless the particular tonal frequencies are an issue.

Résumé

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Executive summary

Background

Defence Research and Development Atlantic was contracted to perform an acoustic survey of the Sable gas pipeline which comes ashore at Country Harbour, Nova Scotia. The experiment involved deploying a hydrophone to perform noise measurements in locations both close to and remote from the pipeline to determine if the pipeline produces significant above-ambient noise. DRDC was responsible for performing the measurements, evaluating the data, and documenting any findings.

Principal results

Sound levels were recorded at various frequency ranges from 0-200 Hz to 0-12800 Hz with efforts focussing on the lower frequencies where pipeline noise might be expected. Baseline measurements taken at locations both away from and near to the pipeline showed mixed results. There was no clear trend with respect to sound level for the highest frequency bands, however, there did appear to be a significant increase in the 0-400 Hz range along with the appearance of some tonal lines. Further examination of points both along the pipeline and perpendicular to the pipeline showed little correlation between sound levels and distance from the pipeline. Analysis of the lower frequency ranges did show the presence of several tones which were not readily visible at the control sites. These tones occurred at 34 Hz, 41 Hz, 50 Hz, 67 Hz, 84 Hz, and 100 Hz. It is theorized that these tones were a result of flow in the pipeline.

Significance of results

For most of the measurements, there was a fairly significant variation of sound level within a single measurement thus, while at some points the identified tones were clearly visible above the background noise, at others it was difficult to distinguish them from the noise without prior knowledge. Thus, while it appears likely that the flow in the pipeline is producing detectable noise, it is not clear that the level is significant, unless the particular tonal frequencies are an issue.

Future work

For the duration of the testing, the amount of transient noise was problematic. Any subsequent testing should consider changing the procedure to include very long sample periods, during which transients may well be averaged out. It was also difficult during the testing to accurately determine the actual background noise level

with which to compare pipeline noise. From the experimental point of view, an improved experiment would include locating the hydrophone close to the pipeline and varying the pipeline flow (including a complete shutdown) multiple times. Obviously, there are there practical difficulties associated with such a plan; however, it may be possible to perform such an experiment coincidental to a planned shutdown.

Layton E. Gilroy; 2003; DRDC Acoustic Survey of Country Harbour Pipeline; DRDC Atlantic ECR 2003-xxx; Defence R & D Canada – Atlantic.

Sommaire

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Layton E. Gilroy; 2003; ; DRDC Atlantic ECR 2003-xxx; R & D pour la
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1 Introduction

Defence Research and Development Atlantic (DRDC) was contracted to perform an acoustic survey of the Sable gas pipeline which comes ashore around Country Harbour, Nova Scotia. The experiment involved deploying a hydrophone to perform noise measurements in locations both close to and remote from the pipeline to determine if the pipeline produces significant above-ambient noise. DRDC was responsible for performing the measurements, evaluating the data, and documenting any findings.

DRDC personnel involved in the acoustic survey portion trial were Mr. Layton Gilroy (Defence Scientist) and Mr. Dave Wheaton (Electrical Technologist). Martec Ltd. also participated in a portion of the trials and arranged for the use of the trials vessel (the *Casha Dawn*), along with the necessary crew.

2 Description of Trial

2.1 Phase 1

In the first attempt to perform the measurements, Messrs. Gilroy, Wheaton and Covill arrived at the Drumhead Wharf at approximately 1300 Monday July 7 and began installing the equipment on Mr. Manthorne's boat, the *Casha Dawn* (see Figure 1). The acoustic measurement system comprises of a tripod-mounted hydrophone (B&K Model 8101), which would be lowered to the sea floor, a 20-metre (approx.) cable connecting the hydrophone to a B & K (Model 2610) amplifier and a HP (Model 35670A) spectrum analyzer. Data plotted on the signal analyzer was saved to 3.5" floppy disk for later analysis. Power to the system was supplied from the boat's inverter, which converts 12 VDC to 120 VAC (Nominal). A backup hydrophone and amplifier were also available. Photographs of the equipment used in the trial are shown in Figures 2 and 3.



Figure 1: *The Casha Dawn*

After the system components were connected, testing began. The system functioned correctly for the first few minutes, only to cease working when the amplifier's main fuse blew (line voltage in). The line voltage was measured and found to be about 130 VAC, which while high, should have been within the capacity of the

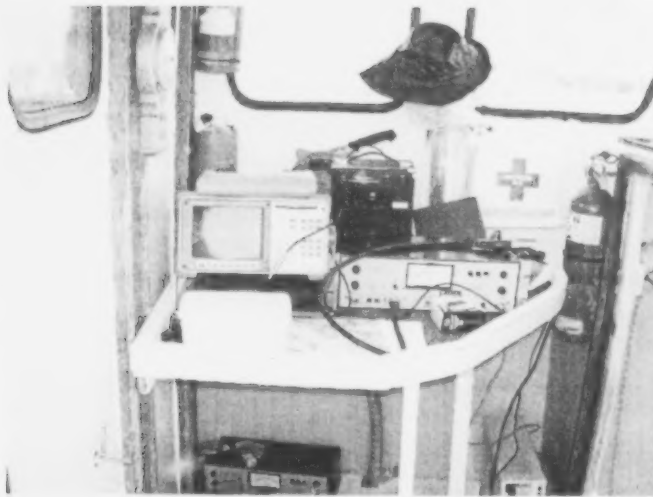


Figure 2: Trials Equipment

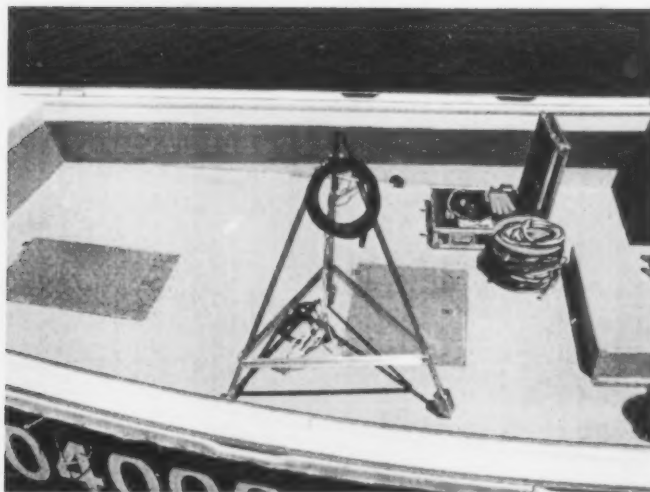


Figure 3: Hydrophone and Tripod

amplifier. The identical backup amp was swapped in, again blowing its fuse after working correctly for a few minutes. At this point, it was surmised that the starting and stopping the boat's engine might have caused an overload, via the inverter, blowing the inline fuses. As measurements were to be taken without the engine running anyway, it was believed that simply having the system powered off when starting/stopping the engine should prevent the fuse blowing. New fuses were acquired (albeit double the capacity of the original, but all that was available), with trials to begin early that evening. The system appeared to be functioning correctly at the wharf, so the boat proceeded to Bear Trap Head (used as a control site for both for the lobster and acoustic measurements) to gather some background sound levels. The hydrophone was lowered to the ocean floor and the measurements were performed and initially the output looked reasonable. The hydrophone tripod was raised and the system re-deployed on the pipeline route about 1 km from shore. Initially outputs from spectrum analyzer output again looked reasonable but suddenly became unreliable (the spectrum were obviously not reflecting actual sound levels). At this point, the over capacity fuse in the amplifier blew and, when replaced, the output remained unreliable. It was felt that the amplifier may have sustained damage, and not wanting to risk damage to the remaining amplifier without a definite solution to the problem, the trials were ended about 2100. Messrs. Gilroy, Wheaton and Covill returned to Halifax, leaving early Tuesday July 8.

Further investigations at DRDC, on Wednesday July 9, showed that the system functioned properly in-air with a better quality inverter providing power from a stand-alone battery. Further testing in a fresh water tank was performed to verify the integrity of the hydrophone cable. It was assumed that the relatively inexpensive inverter used on the vessel was producing power containing high frequency voltage spikes which were tripping the amplifier fuses. No damage to the amplifier was evident and the signal analyzer showed no ill effects at any time from the power supplied.

2.2 Phase 2

With the equipment problems resolved, Messrs. Gilroy and Wheaton returned to the Drumhead Wharf at approximately 1300 Thursday July 17 and began re-installing the equipment on the *Casha Dawn*. The acoustic measurement system was essentially the same as that used previously, but updated with a Pro SINE 1800 inverter together with DRDC-owned 12V marine batteries. The system functioned flawlessly at dockside, so it was decided to proceed to the site. Weather at the time was foggy with a small amount of chop from light winds and about a 1-metre, long-period swell. DRDC had proposed measuring a select number of sites to attempt to determine background levels and these measurements were attempted first. The first location was Bear Trap Head (roughly 45 09.296 N,

61 39.672 W). The second was nominally over the pipeline, but well out from shore (45 08.936 N, 61 38.307 W, designated "Pipeline End") and the third was Island Harbour (45 08.660 N, 61 37.058 W). The final "initial" point was close to shore on the pipeline route (45 09.338 N, 61 37.767 W) and was designated P4. Sound levels were recorded at these four points covering frequency ranges of 0-400 Hz, 0-1.6 kHz, and 0-12.8 kHz. Previous discussions had indicated that, if the pipeline was producing significant noise, it should be low frequency - on the order of a few hundred Hz at the highest. As such, it was decided to record all subsequent sound levels over the 0-400 Hz and 0-800 Hz ranges. Later, a 0-200 Hz range was also examined. Positions were recorded using a Differential Global Positioning System (DGPS) and depths (in fathoms) with a bottom sounder, both available on the *Casha Dawn*.

After the initial measurements, a series of 5 points were examined at roughly equal intervals starting at P4 and following the expected course of the pipeline. The intended interval was 50m, but the interval was estimated only and the final value was likely greater. These points were designated P4+50, P4+100, ..., P4+250 to match the planned intervals. Upon completion of these measurements, the boat returned to the 2nd of these 5 points (P4+100, dubbed PX) and measurements were made at 7 locations in a line (roughly) perpendicular to the pipeline with similar intervals to those used previously. These points were designated with the increment and whether they were East or West of the baseline (PX+50E, PX+50W, etc.). There was also an initial designation of "+" for east and "-" for west (PX+50, PX-50, etc.). Note that during the entire set of measurements, visibility was extremely limited, so it was not possible to determine visually if there were sources of acoustic interference. Also, surf noise from the swell was audible at all times. During the measurements, there were often unexplained noise spikes or increases in the overall level. These measurements were not recorded as they were deemed to be transients. Upon completion of the above measurements, the boat returned to the wharf (at 2000) with a brief stop at a secluded cove (45 08.417 N, 61 36.626 W) to record a final background measurement. After a partial review of the data that night, it was determined that several of the measurements "looked too high" and should be re-examined. These included Bear Trap Head, P4, PX+100E, and PX+100W. The team reassembled at 0730 on July 18th. It was again extremely foggy, there was virtually no wind and the swell was slightly larger (> 1.5m). The above points were re-measured in the 0-400 Hz band and then a second perpendicular line of points was measured starting at the 4th of the 5 points discussed above (P4+200, dubbed PX2). The line consisted of 8 points (4 either side) with a spacing slightly larger than that used the previous day (designated PX2+50E, PX2+50W, etc.). These were, unfortunately, initially designated PX2±NY, where N was the number of the increment and the "+" was for points west and the "-" for points east. The complete set of data points are shown in Figures 4 and 5.

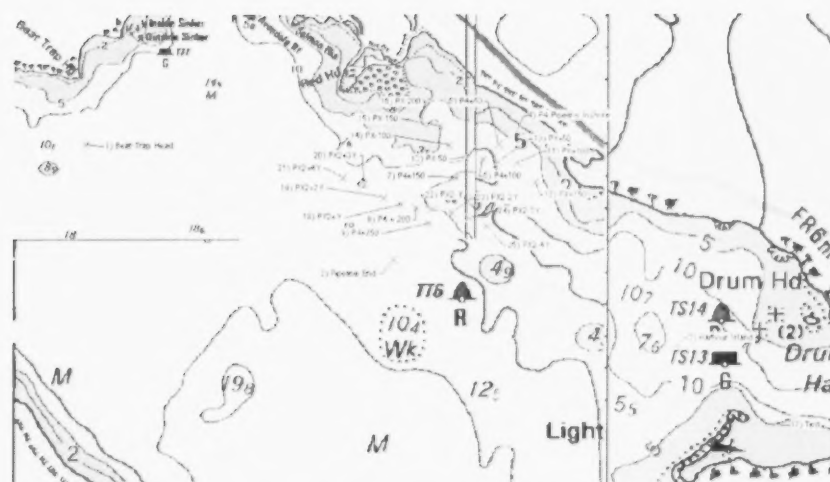


Figure 4: Measurement Points

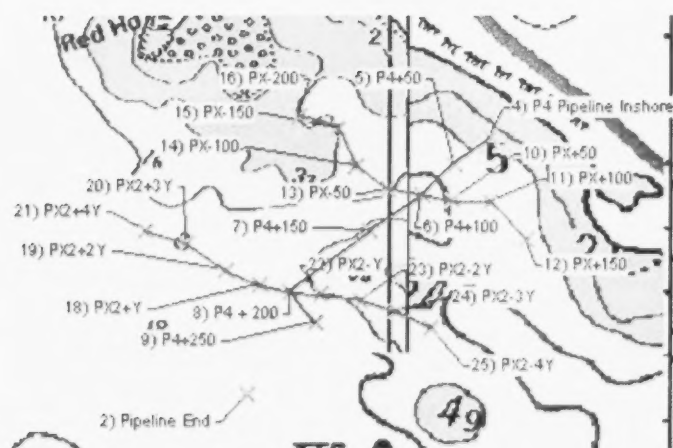


Figure 5: Measurement Points (Zoom)

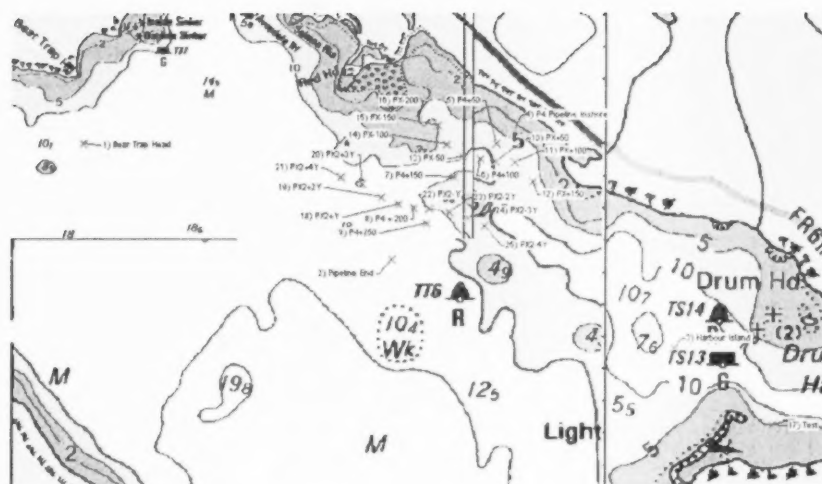


Figure 4: Measurement Points

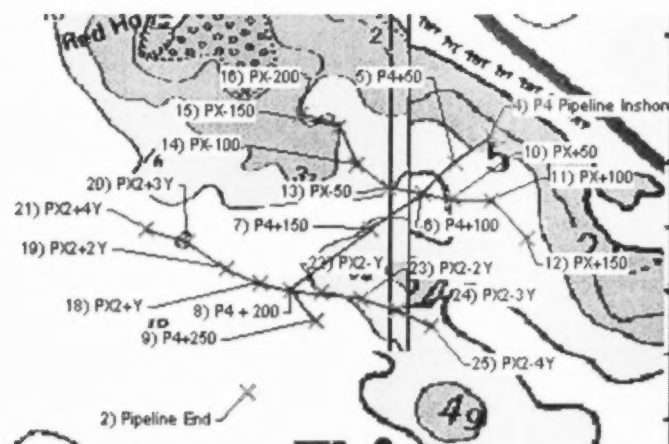


Figure 5: Measurement Points (Zoom)

After these measurements, it was decided that sufficient data had been collected and, without further analysis, performing more measurements would not be productive. Note that, on this day, there seemed to be much more transient noise, making it much more difficult to obtain individual recordings. There was no obvious explanation for the increase in transient noise. The team returned to the wharf and packed up the gear finishing by roughly 1130, returning DRDC later that afternoon.

3 Results and Discussion

The small amount of data collected during the first (abortive) trial was deemed unreliable and discarded. This section describes the data collected during the second trial and attempts to present it in a coherent fashion.

Of some interest was the relative positioning of the measurement points with respect to the actual location of the pipeline. A separate DRDC group was tasked with performing magnetic and electric field measurements of the pipeline. This group was able to accurately locate the pipeline using their measurements. This location is compared to our measurement points in Figure 6. As can be seen from the figure, there was some offset from the actual pipeline location, although as will be seen, this may not be significant. Depths varied from a low of 4 metres at the "Cove" location to more than 18 metres at the "Pipe End" location.

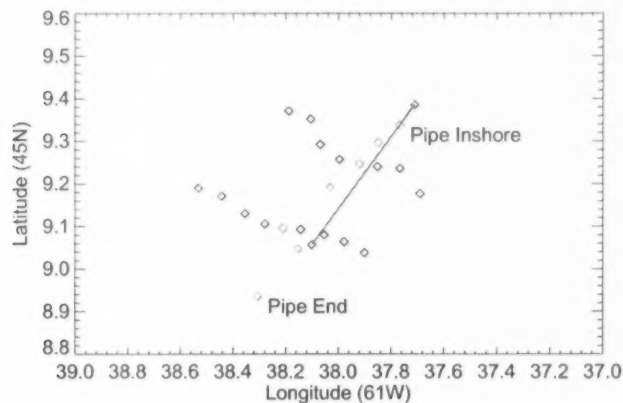


Figure 6: Comparison of Measurement Points with Pipeline Location

The following plots are records of the data collected at the various measurement points. These data are available in an Excel spreadsheet and as separate data files on a CD. The horizontal axis in all the plots is the frequency in cycles per second or Hertz (Hz). The vertical axis is the relative sound level in decibels (dB). The dB scale will mean that a sound that is 20 dB higher has a sound pressure that is 10 times higher ($\text{dB} = 20 \log_{10}(p_1/p_2)$). Note that the data is only presented as a relative sound level without conversion to actual noise levels, which could be done by including the calibration factor from the hydrophone and the gain levels used on the amplifier (which were recorded). As the relative sound level was deemed to be the important factor, these levels were presented. Note the "diamond" symbol, where present, marks the 60 Hz noise line (interference from electrical sources)

and its harmonics (120 Hz, 180 Hz, etc.) and a red asterisk is used to indicate other frequencies of interest.

A common feature to all these plots was a rise in the sound level at the lowest frequencies. This characteristic is seen in many underwater noise measurements and is primarily a result of a general increase in ambient noise at the lowest frequencies, although, in some cases, there may be contributions due to the response of the hydrophone or other equipment (particularly accelerometers) at the low frequencies. Due to this, any data below about 25 Hz on the 0-400 Hz and 0-200 Hz plots should be regarded as suspect and discarded. Note that this level is somewhat arbitrary, based on DRDC's experience and analysis of the data.

3.1 Baseline Measurements

The first set of plots show an overall comparison of the sound levels at a number of locations over various frequency ranges. These baseline measurements are plotted for 12.8 kHz (Figure 7), 1600 Hz (Figure 8), and 400 Hz (Figure 9).

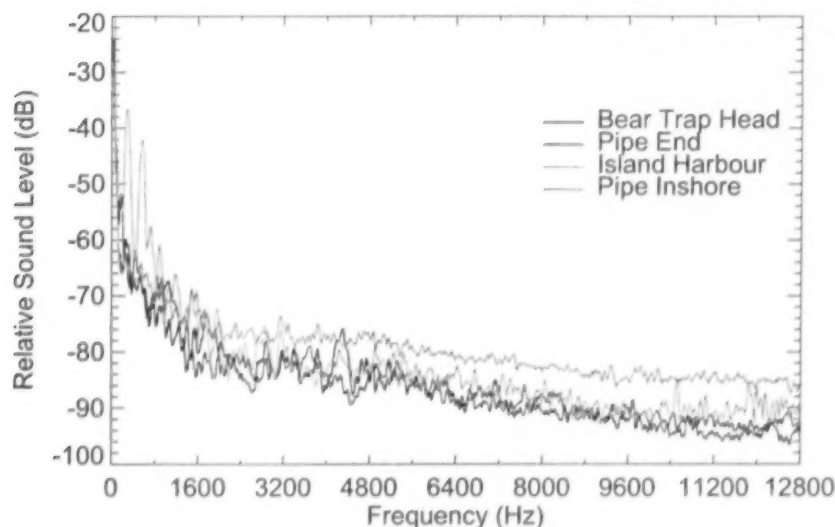


Figure 7: Baseline Measurements (12.8 kHz)

In Figure 7, it can be seen that, while the inshore pipeline location showed higher noise levels, there was no apparent pattern to the curves (as the other pipe location often had the lowest noise levels). The large spikes on the Island Harbour curve

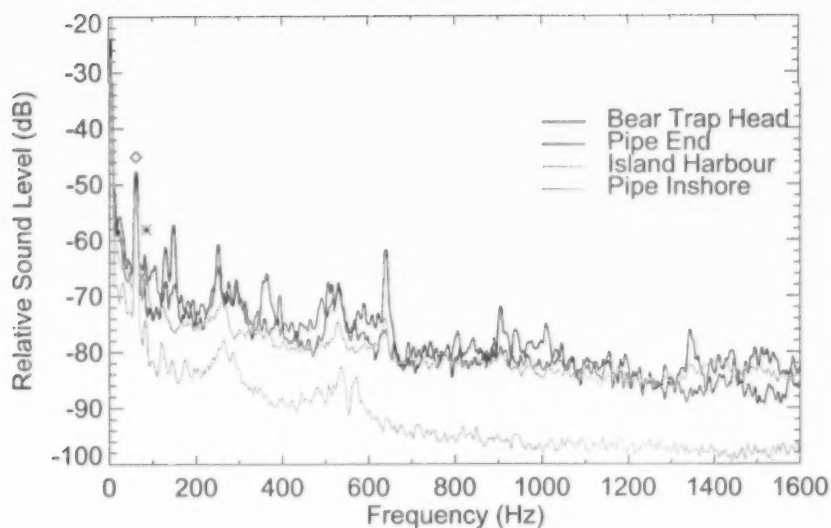


Figure 8: Baseline Measurements (1600 Hz)

are believed to be transients, which were not discarded at the time. This lack of clear pattern was also apparent in Figure 8, with the Island Harbour curve being substantially lower than the other closely grouped ones. This curve showed the first obvious appearance of the 60 Hz electrical noise signal and a possible tone at about 84 Hz (this will be discussed later). There were some broad higher frequency peaks shown in this figure (254 Hz and 640 Hz), but they show up on more than just the pipeline curves, so their origin cannot be traced.

The final baseline plot was the 0-400 Hz plot shown in Figure 9. In this figure, the two pipeline curves showed noticeably higher overall noise levels than the other control locations. While this was significant, it may also have been fortuitous, as this effect was not seen in the previous two figures. However, it should not be discounted, as it was expected that, if the pipeline were producing significant noise, it would likely be low frequency (below several hundred Hz). In this figure, 60 Hz and two of its harmonics were prominent. Also, some low frequency tones were beginning to emerge (67 Hz and 84 Hz) and, while there was some more broadband activity around 130 Hz, 150 Hz and 250 Hz, this was only apparent on the pipe end curve.

While the baseline measurements did not show significant pipeline noise levels in an overall sense (over the audible range), there did appear to be a significant

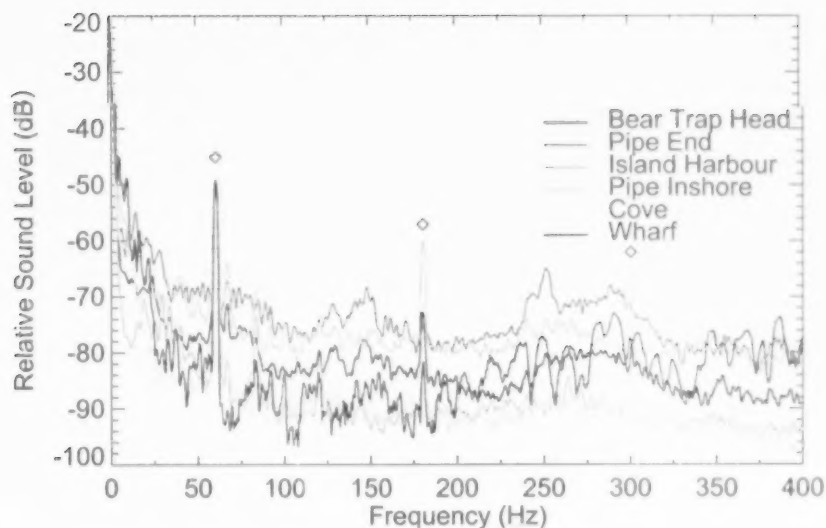


Figure 9: Baseline Measurements (400 Hz)

increase in the 0-400 Hz range along with the appearance of some tonal lines. The latter issue will be discussed in the following sections.

3.2 Measurements Along Pipeline

The following two sets of plots (Figure 10 and Figure 11) show the results of the measurements made along the pipeline route over the 0-400 Hz and 0-800 Hz ranges. In neither plot was there any significant difference in sound levels with respect to measurement location, nor would one expect such a thing based on position alone. Some effect from either depth or distance from shoreline might be expected, but none was seen, possibly due to the hydrophone being so close to the bottom relative to any other dimension.

In Figure 10, two significant tones were visible across all the curves, 33 Hz and 84 Hz (± 1 Hz). In Figure 11, six significant tones were visible, 34 Hz, 41 Hz, 50 Hz, 67 Hz, 84 Hz, and 100 Hz (± 1 Hz). After reviewing Figure 11, most of these six tones were also visible in Figure 10, although not on all the curves. Note that these may not be six separate tones, but may be harmonic pairs (34 and 67 Hz, 41 and 84 Hz, and 50 and 100 Hz) with one being either the upper or lower harmonic of the other (it would be more common for the upper frequencies to be

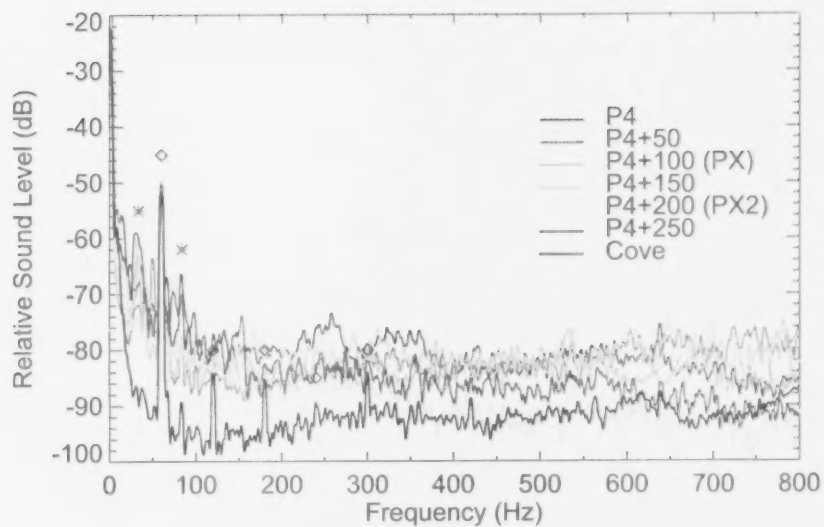


Figure 10: Measurements Along Pipeline (800 Hz)

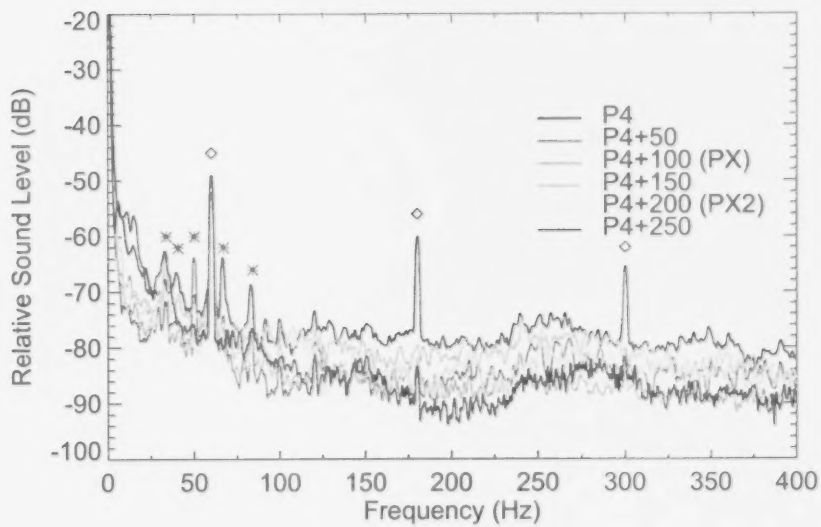


Figure 11: Measurements Along Pipeline (400 Hz)

the harmonic of the lower). These tones may well have their source in the pipeline, as they were not clearly visible at the control locations. Note that, while these tones were clearly distinguishable, they did not always have significantly different sound levels than any other arbitrary frequency.

3.3 Measurements Perpendicular to Pipeline

Two sets of measurements were made in locations running perpendicular to the nominal path of the pipeline. Figures 12 to 14 show the results for the inshore transect running through point PX and Figures 15 and 16 show the results for the transect running through PX2.

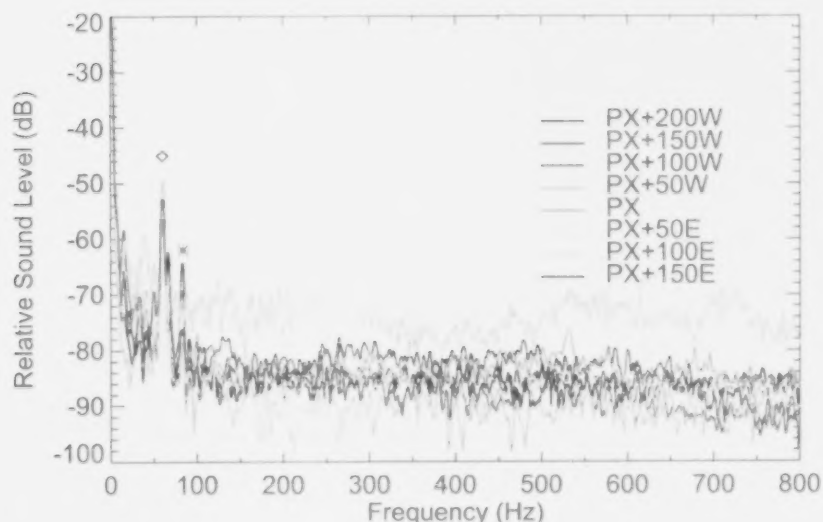


Figure 12: Inshore Transect at PX (800 Hz)

Examining all three plots from the inshore transect, no clear pattern emerged with respect to location or distance from the pipeline. In Figure 12 (0-800 Hz), the "PX+100E" curve appeared to be an anomaly as it was significantly higher than the others for no apparent reason. In Figure 13 (0-400 Hz), all six tones described above were clearly visible. At this point, it was decided to narrow down the frequency band even more and the 0-200 Hz range was used (double the resolution from the 400 Hz range). In Figure 14, the measurements from the Bear Trap Head and Cove locations were included for reference. It can be seen that for these two locations, the tones were not particularly visible, while they are clearly visible at

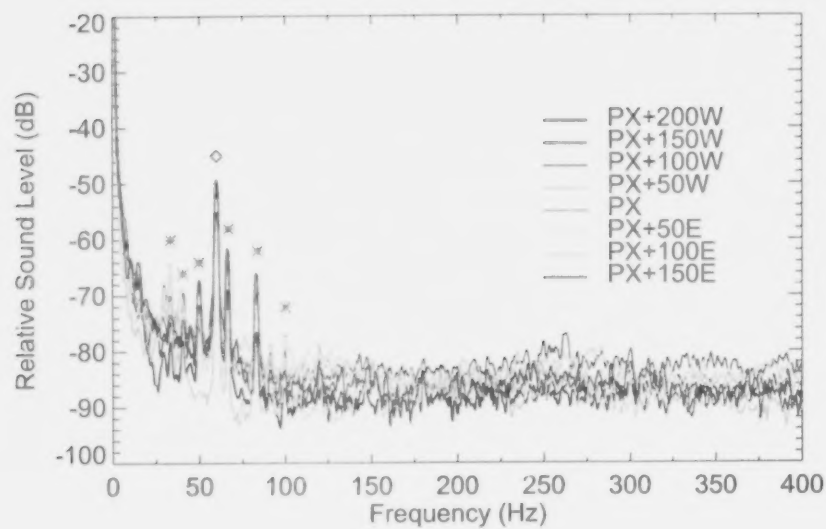


Figure 13: Inshore Transect at PX (400 Hz)

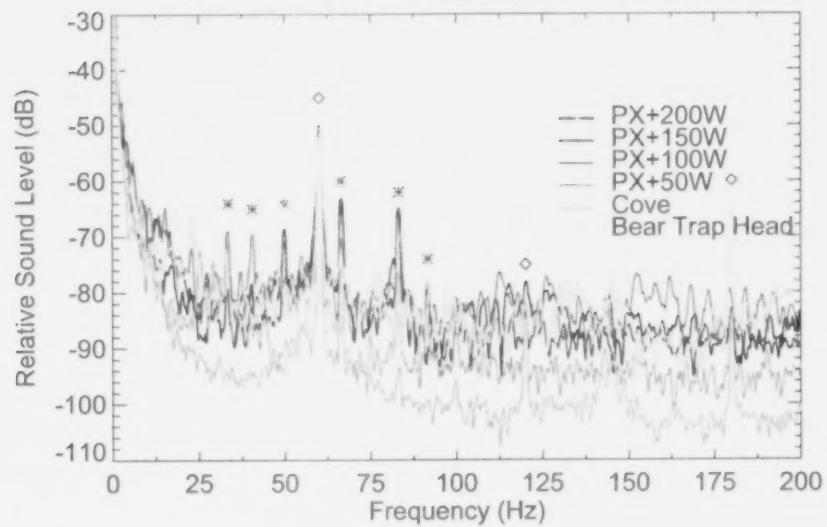


Figure 14: Inshore Transect at PX (200 Hz)

all transect locations. This was a strong indication that the tones originated in the pipeline. It can also be seen that the Bear Trap Head location was quite noisy over this frequency range while the Cove location was extremely quiet.

During the second transect, the 800 Hz measurements were only recorded for some locations as the measurements were showing considerable scatter and the level of transients were hindering the data collection. As such, Figure 15, only shows five locations and, as can be seen from the figure, the low frequency tones were not generally visible. The figure does seem to show that the general noise level increased with increasing distance from the pipeline, but this effect appears marginal at best.

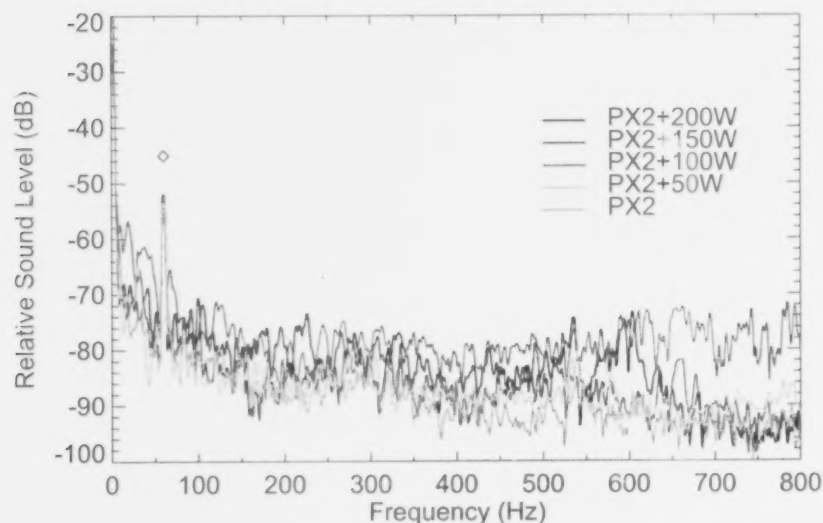


Figure 15: *Transect at PX2 (800 Hz)*

Figure 16 shows the full transect for the 400 Hz band. As with the 800 Hz band, the tones seen earlier were not as visible. In this case, there was no discernable correlation between the various curves and the measurement locations.

As the low frequency tones appeared frequently near the pipeline, the data from one transect was examined in more detail to determine if there was any correlation between location and sound level for these tones. The plot in Figure 17 shows the levels of the more dominant tones with respect to location. As can be seen, there was no obvious correlation. As the sound propagation in shallow water is a complex, frequency dependent phenomenon, it was not clear if a pattern should have been obvious without extensive analysis.

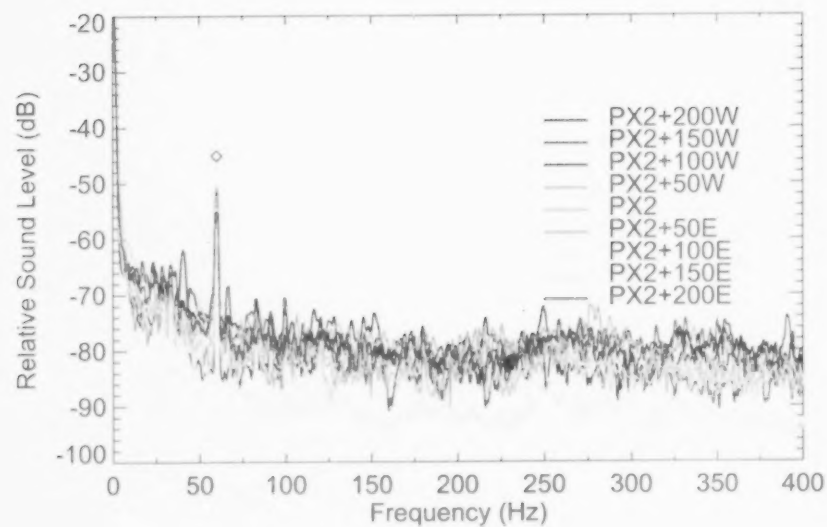


Figure 16: Transect at PX2 (400 Hz)

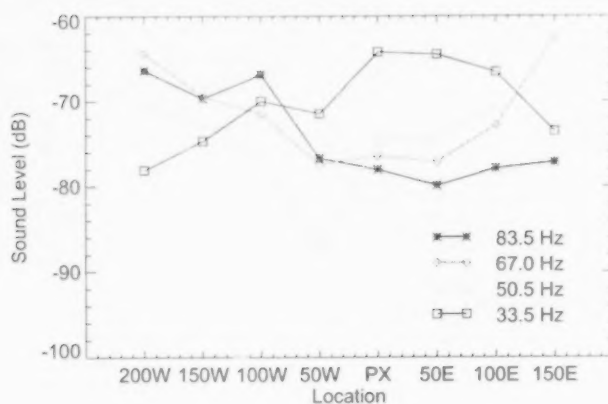


Figure 17: Variation of Tone Levels with Location

4 Discussion and Recommendations

Acoustic data over a range of frequencies were collected around the gas pipeline in Country Harbour to determine if the pipeline generated noise which could be discriminated from normal background levels. The measurements were all made with a hydrophone deployed on a tripod to maintain a 1 metre standoff from the ocean bottom beneath a fishing vessel. Sound levels were recorded at frequency ranges of 0-200 Hz, 0-400 Hz, 0-800 Hz, 0-1600 Hz, and 0-12800 Hz with efforts focussing on the lower frequencies where pipeline noise might be expected.

Baseline measurements taken at locations both away from and near to the pipeline showed mixed results. There was no clear trend with respect to sound level for either the 12800 Hz band or the 1600 Hz band, however, there did appear to be a significant increase in the 0-400 Hz range along with the appearance of some tonal lines. Further examination of points both along the pipeline and perpendicular to the pipeline showed little correlation between sound levels and distance from the pipeline.

Analysis of the lower frequency ranges did show the presence of several tones which were not readily visible at the control sites. These tones occurred at 34 Hz, 41 Hz, 50 Hz, 67 Hz, 84 Hz, and 100 Hz (± 1 Hz). Every tone was not visible at every pipeline location, but the majority of locations showed several. These may be individual tones or they may be combinations of a primary frequency and a harmonic (e.g. 34 Hz primary and 67 Hz harmonic). It is theorized that these tones were a result of flow in the pipeline.

It should be noted that for most of the measurements, there was a fairly significant variation of sound level within a single measurement. Levels can vary by up to 20 dB (a factor of 10) over a range of tens of Hz (with some measurements showing more variation, some less). While at some points the identified tones were clearly visible above the background noise, at others it was difficult to distinguish them from the noise without prior knowledge of their existence. Thus, while it appears likely that the flow in the pipeline is producing detectable noise, it is not clear that the level is significant, unless the particular frequencies are an issue.

For the duration of the testing, the amount of transient noise was problematic. Typically measurements were rejected based on a visual identification (at the analyzer) of a transient signal. These transients were typically quite strong and overwhelmed the "normal" signal levels. Any subsequent testing should consider changing the procedure to include very long sample periods (even to many hours), during which transients will be averaged out. Unfortunately, there would be no guarantee that there would not be sufficient transients to overcome this plan as well, although such an occurrence would be instructive in itself.

It was also difficult during the testing to accurately determine the actual background noise level with which to compare pipeline noise. Due to the above transients, the fact that the background must be measured at a different location, and the inherent variability in such measurements, it is not clear what the actual background noise level should be. From the experimental point of view, a much improved experiment would include locating the hydrophone over and close to the pipeline and varying the pipeline flow (including a complete shutdown) multiple times. Obviously, there are there practical difficulties associated with such a plan; however, it may be possible to perform such an experiment coincidental to a planned shutdown.

Appendix - Pipeline Survey Proposal

Estimate for Pipeline Noise Measurement

Trial Description

Equipment will be loaded at DRDC - Atlantic into a rental car and the team will travel to Country Harbour. Upon arrival, the team will load the equipment on the vessel and test its operation. It is expected there should be sufficient time to sail to a position close to the expected trial's location and perform a number of acoustic measurements to test the equipment and establish some baseline data. The vessel will then return to shore for the night. A full set of acoustic measurements will be performed the following day to attempt to determine if the pipeline is generating significant sound levels. It is expected that the measurements would consist of a survey perpendicular to the pipeline as well as one along the path of the pipeline with sound level spectra being measured at established range intervals. The customer will be responsible for positioning the vessel relative to the pipeline. Upon completion of this survey (a duration of up to one and one half days), the equipment will be unloaded from the ship to the rental car and the team will return to Dartmouth. A draft report describing the measurements and the results will be produced within two weeks and submitted to Martec. Following any corrections, a final report will be submitted within two weeks of receiving any comments on the draft report.

Dates

Trial is expected to require up to three days (weather permitting).

Requirements

The customer will provide:

- Trials vessel
- Shipboard AC power or AC generator
- Dry working area
- Rental car
- Overnight security for equipment

Equipment Provided by DRDC

- HP 35670A 4-channel signal analyzer

- 2 B&K 8101 hydrophones
- B&K 2610 Measuring amplifier
- Multimetrics AF-220 filter
- UPS
- Laptop PC
- Audio speaker

Optional:

- Accelerometer and charge amplifier to measure shipboard vibrations.
- Handheld GPS to establish measurement locations.
- 600W power inverter to provide quiet power to instrumentation.
- Hydrophone tripod.

Personnel

Layton Gilroy, Scientist, DS-5

David Wheaton, Technologist, EG-6

Expected Schedule

Day 1

0800 Load equipment in Martec-provided vehicle and depart DRDC Dartmouth for Country Harbour.

1300 Load equipment on vessel provided, transit to pipeline location, and perform background/test acoustic measurements.

1700 Return to shore (RTS).

Day 2

0800 Transit to pipeline location. Perform detailed acoustic survey around pipeline.

1700 RTS.

Day 3

0800 Transit to pipeline location. Complete detailed acoustic survey around pipeline.

1100 RTS. Load equipment in vehicle and return to Dartmouth.

Acoustic Measurements

All sound level measurements will be made using the B&K hydrophones connected to the HP signal analyzer. Sound level spectra will be recorded over a specified frequency range, which will be determined based on baseline and initial survey measurements. Data will be recorded on tape if required and any measured spectra will be saved to disk. If deemed necessary, raw signals will be filtered before being sent to the signal analyzer.

On the first day of trials, several spectra will be measured at some distance from the pipeline to establish background noise levels. For the acoustic survey, the vessel will be positioned directly over the pipeline and sound level spectra will be recorded. The vessel will then move 25m (or another distance to be determined upon further discussion) along the pipeline and another spectrum will be measured. This will be repeated until it is possible to determine if there is significant variation along the pipe. After selecting a particular point along the pipe, the vessel will then move perpendicular to the pipe to a distance of 250m from the pipeline and sound level spectra will again be recorded. This will be repeated at set distance intervals with the vessel moving closer to and traversing the pipeline. Based on these measurements (for which up to 1.5 days have been allotted), the team will determine if any other measurements are required. Upon completion of the trial, DRDC personnel will unload the vessel, load the equipment in the rental vehicle, and return to DRDC.

To secure the DRDC equipment, either time must be allowed for DRDC personnel to unload the vessel each night or security acceptable to DRDC must be provided at the vessel.

Upon completion of the trial, DRDC will prepare a report in a form acceptable to the customer and will review that report based on comments provided by the customer.

Options:

1. Initial planning involved lowering the hydrophone over the side of the vessel to a prescribed depth. A possible option would be for DRDC to construct a tripod on which the hydrophone is mounted and this tripod would then be lowered to the bottom, thus positioning the hydrophone at a set distance from the bottom.
2. Geophones could be rented from GES and placed on the bottom (at specified locations) and then left in place to record over a longer time period. While this may increase the data gathering time, it will limit the number of sites measured. It may provide seismic data as well as acoustic data. Cost: Preliminary estimate of \$1000 per unit.
3. The trial would significantly benefit if it were possible to have a scheduled

shutdown of the pipeline, thus providing a valuable baseline measurement. Arrangements would have to be made to have the pipeline shut down early in the trial at which time a set of measurements would be made. Measurements would then also be made during the subsequent start-up and continuous operation. Question: are there multiple operating states of the pipeline?

Costs

Estimated costs for the trials (not including travel and living) are shown below. Actual personnel and equipment costs will be based on actual hours worked (including travel).

Scientist		
-Trials	9 hours x 3 days @ \$160/hour	\$4320.00
-Analysis and reporting	15 hours @ \$160/hour	\$2400.00
Technologist	9 hours x 3 days @ \$120/hour	\$3240.00
Equipment rental	3 days @ \$1000/day	\$3000.00
Subtotal		\$12960.00
Administrative fee	10%	\$1296.00
Total		\$14256.00

Note that this does not include the costs of renting any ocean bottom seismometers.

Travel and Living

Should these expenses not be provided by the customer, they will be billed at appropriate government rates. Hotel expenses will be billed based on the actual cost (receipts provided) and a daily per diem of \$62.00 (\$10.70 for breakfast, \$10.45 for lunch, \$29.35 for supper, and \$11.50 for incidentals) will be charged for meals and incidentals. Should the customer not provide a transport vehicle, a rental car will be obtained and all related charges will be billed to the customer.

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Defence Research and Development Atlantic was contracted to perform an acoustic survey of the Sable gas pipeline which comes ashore at Country Harbour, Nova Scotia. The experiment involved deploying a hydrophone to perform noise measurements in locations both close to and remote from the pipeline to determine if the pipeline produces significant above-ambient noise. Sound levels were recorded at various frequency ranges from 0-200 Hz to 0-12800 Hz with efforts focussing on the lower frequencies where pipeline noise might be expected. Baseline measurements taken at locations both away from and near to the pipeline showed mixed results. There was no clear trend with respect to sound level for the highest frequency bands, however, there did appear to be a significant increase in the 0-400 Hz range along with the appearance of some tonal lines. Further examination of points both along the pipeline and perpendicular to the pipeline showed little correlation between sound levels and distance from the pipeline. Analysis of the lower frequency ranges did show the presence of several tones which were not readily visible at the control sites. These tones occurred at 34 Hz, 41 Hz, 50 Hz, 67 Hz, 84 Hz, and 100 Hz. It is theorized that these tones were a result of flow in the pipeline. For most of the measurements, there was a fairly significant variation of sound level within a single measurement thus, while at some points the identified tones were clearly visible above the background noise, at others it was difficult to distinguish them from the noise without prior knowledge. Thus, while it appears likely that the flow in the pipeline is producing detectable noise, it is not clear that the level is significant, unless the particular tonal frequencies are an issue.

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acoustic
survey
pipeline
undersea
measurements
tones
low frequency